Skills Research Initiative
Initiative de recherche sur les compétences

Adjustments in Labour Markets for Skilled Workers in Canada

Daniel Boothby (Industry Canada)
Bruno Rainville (Human Resources and Skills Development Canada)

Working Paper 2004 C-01

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B. Employer-Supported Training;
C. Adjustments in Markets for Skilled Workers;
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B. la formation en entreprise;
C. l'adaptation du marché du travail aux travailleurs spécialisés;
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Abstract

Meeting the challenge of the 21st century Canadian economy through rapid expansion of the highly skilled labour force involved in innovation will require important labour market adjustments. The purpose of the roundtable for which this paper was prepared is to discuss a series of issues concerning these adjustments in order to develop a medium-term research program on these issues. They include:

- What are the types and levels of skilled labour Canada needs and will need in building an innovative economy?
- Where does Canada stand now in the supply of these types of skilled labour? What are the current conditions in markets for these types of skilled labour?
- Does Canada have the institutional set-up needed to achieve the required adjustments? What institutional barriers are there to adjustments? Are there institutional changes that could facilitate adjustments?

Section 1 of this paper takes up the first two points raised above. The section begins by discussing issues that concern the links between skilled workers and innovative activity. A better understanding of these links is a key element in developing a framework of indicators of how Canada is faring in the provision of the human resources required by a greatly increased level of innovation. Section 1 concludes by presenting and discussing a number of indicators of Canada's current situation.

Adjustments in sectors, regions and firms and in their institutional environment are discussed in Section 2 of this paper. The fourth point raised above—the role of institutions in these adjustments—is central to developing policy for ensuring an adequate supply of skilled labour in support of greatly increased levels of innovation. The research program outlined in Section 2 would seek to identify institutional constraints to adjustments (other than constraints due to the institutional structure of Canada's post-secondary educational system, which are discussed in the issues paper Montmarquette and Boisclair, 2004).

Section 3 of the paper is a brief conclusion.

Résumé

Pour relever le défi que représente l'économie du XXIe siècle en accélérant l'expansion de la main-d'œuvre hautement qualifiée qui exerce des activités novatrices, le marché du travail devra faire l'objet d'une importante adaptation. Le but de la table ronde pour laquelle ce document a été rédigé consiste à discuter d'un certain nombre de questions concernant l'adaptation nécessaire en vue de l'élaboration d'un programme de recherche à moyen terme. Il s'agit notamment des questions suivantes :

- Quels sont les types et les niveaux de main-d'œuvre qualifiée dont le Canada a besoin pour bâtir une économie novatrice ?

- Quelle est la situation actuelle de l'offre de ces types de main-d'oeuvre au Canada? Quelle est la conjoncture actuelle des marchés pour ces types de main-d'œuvre qualifiée ?
- Le Canada dispose-t-il du cadre institutionnel nécessaire à la réalisation de cette adaptation? Quels sont les obstacles institutionnels à l'adaptation? Y a-t-il des changements institutionnels qui pourraient faciliter cette adaptation?

La première partie du document porte sur les deux premiers points susmentionnés. On y traite tout d'abord des questions qui concernent les liens entre les travailleurs qualifiés et l'innovation. Une meilleure compréhension de ces liens est primordiale à l'élaboration d'un cadre d'indicateurs permettant d'évaluer la performance du Canada en matière d'offre de ressources humaines qu'exige le degré considérablement plus élevé d'innovation. La première partie se termine sur la présentation et l'analyse de certains indicateurs de la situation actuelle du Canada.

L'adaptation des secteurs, des régions et des entreprises ainsi que du milieu institutionnel est abordée dans la deuxième partie du document. Le quatrième point susmentionné — le rôle des institutions dans cette adaptation — est au cœur de l'élaboration des politiques visant à garantir une offre suffisante de main-d'œuvre qualifiée compte tenu des niveaux sensiblement accrus d'innovation. Le programme de recherche dont il est question dans la deuxième partie vise à recenser les obstacles institutionnels à l'adaptation (autres que les obstacles liés à la structure institutionnelle du système d'enseignement postsecondaire au Canada, lesquels sont abordés dans le document de Montmarquette et Boisclair, 2004).

La troisième partie du document contient une brève conclusion.

0. Introduction

0.1. Overview

To build a 21st century economy, Canada needs to increase its capacity to innovate, in order to achieve continued productivity growth and rising standards of living. In today's knowledge-based economies, skilled workers are indispensable to an innovative economy. *Knowledge Matters* (HRDC, 2002, p.7) states that "the knowledge-based economy means an ever-increasing demand for a well-educated and skilled workforce..." Innovation involves, not only new techniques, but also new forms of knowledge and skills embodied in skilled workers. Consequently, a key goal for Canada is to "Develop the most skilled and talented labour force in the world". (*Achieving Excellence*, Industry Canada, 2002, p.60).

Reaching the goal of a more innovative Canadian economy therefore is subject to meeting a number of key human resources challenges. Among these is ensuring that the skilled labour force is, and will continue to be, of sufficient quantity and quality to support the expansion of innovative activities by industry. This is what *Achieving Excellence* refers to as the skills challenge; *Knowledge Matters* speaks of "making sure that Canadians have the skills and knowledge required for today's economy and society" as a "national challenge" (p.9).

As demand shifts rapidly among advanced, high-growth industries, skilled workers increasingly will need to move between industries and regions and to develop new skills over their work life. Workers who can adapt to rapid change, and markets for skilled labour that facilitate adjustment, are further human resources conditions for a more innovative economy.

To meet the challenge of the 21st century economy through rapid expansion of the skilled labour force involved in innovation will require important labour market adjustments. The purpose of the roundtable for which this paper was prepared is to discuss a series of issues concerning these adjustments in order to develop a medium-term research program on these issues. They include:

- What are the types and levels of skilled labour Canada needs and will need in building an innovative economy?
- Where does Canada stand now in the supply of these types of skilled labour? What are the current conditions of supply and demand in markets for these types of skilled labour?
- How big are the adjustments required to meet Canada's target for research and development activity? How difficult will it be for labour supply to meet the resulting growth in demand for certain types of skilled labour?

- Does Canada have the institutional set-up needed to achieve the required adjustments? What institutional barriers are there to adjustments? Are there institutional changes that could facilitate adjustments?

0.2 Plan of the paper

Section 1 of this paper takes up the first two points raised above. The section begins by discussing issues that concern the links between skilled workers and innovative activity. A better understanding of these links is a key element in developing a framework of indicators of how Canada is faring in the provision of the human resources required by a greatly increased level of innovation. Section 1 concludes by presenting and discussing a number of indicators of Canada's current situation.

The third point raised above concerns the size of adjustments required to meet Canada's research and development goals and how difficult it will be to meet the resulting increased demand for skilled workers. This point will be taken up at the roundtable in a presentation by Barney Laciak of the Natural Sciences and Engineering Research Council (NSERC) which updates Laciak (2002). The presentation considers in detail the human resource supply and demand adjustments required in the market for natural scientists and engineers in order to reach Canada's research and development goals through 2010.

Adjustments in sectors, regions and firms and in their institutional environment are discussed in Section 2 of this paper. The fourth point raised in the bullets above—the role of institutions in these adjustments—is central to developing policy for ensuring an adequate supply of skilled labour in support of greatly increased levels of innovation. The research program outlined in Section 2 would seek to identify institutional constraints to adjustments, other than constraints due to the institutional structure of Canada's post-secondary educational system. (How Canada's post-secondary educational system adjusts to labour market signals is the subject of a paper prepared for the roundtable by Claude Montmarquette and David Boisclair, 2004).

Section 2 discusses institutional factors that might impede entry, mobility or substitution, institutional arrangements that could facilitate adjustments by providing new skills, the provision of labour market information for skilled workers and market imperfections. The final subsection of section 2 points out that while the research program outlined in the issues paper for the most part concerns supply side impediments to adjustments in markets for skilled workers, the relative importance of supply-side and demand-side impediments needs to be considered.

Section 3 of the paper is a brief conclusion.

0.3 An example

A recent paper by Paul Romer (2001) on the subject of policies for increasing innovation is an excellent illustration of an analysis moving from a theoretical model through an examination of institutions to policy directions. Romer first uses a model of the

innovation process to identify what he views as the critical human resources, then identifies institutional factors that may prevent labour market adjustment and, finally, suggests policies to overcome these institutional barriers and benchmarks for measuring the success of these policies.

Romer begins with the idea that it is possible to substantially increase growth rates by increasing innovation. His method for increasing innovation, based on his earlier work (for example, Romer, 1990, which is discussed below in Section 1) is to increase the size of the knowledge-producing sector, which he identifies with scientists and engineers working in research and development. Romer's work would thus tend to identify the number of scientists and engineers engaged in research and development as the key benchmark of an economy's innovative capacity.

Romer points out that subsidies to demand for research and development will simply result in increased income for scientists and engineers currently in the research and development sector if there is no supply response. He then presents a series of reasons that a supply response may be weak. These reasons are rooted in the institutional characteristics of post-secondary institutions. Among them are: that post-secondary institutions do not provide adequate labour market information to students who might consider entering science and engineering fields; and that post-secondary institutions may respond to increased student demand for places in science and engineering by becoming more selective in admitting the same number of students, rather than by increasing admissions.

Romer concludes with a series of goals, benchmarks for measuring progress towards these goals and programs to attain the goals. For example, one goal is increasing natural sciences and engineering undergraduate degrees to 10% of undergraduate degrees in the U.S. by 2020 (from 5.4%). The benchmark suggested is the percentage of 24 year olds with these degrees (which can be compared with other countries). The program is training grants in these areas. Another goal is redressing the imbalance between subsidies to demand and subsidies to supply for scientists and engineers in the private sector. Romer suggests benchmarking this goal by relating expenditures on his proposed program (portable fellowships to graduate students) to those for various research and development subsidies and tax credits.

The scope of Romer's paper is larger than that of this roundtable. The research program to be developed here will aim at better identifying the critical human resources for innovation, the scope of required adjustments and institutional changes that might facilitate adjustment. Romer's paper may provide a useful model for this process.

In addition to the issues to be discussed at this roundtable, population aging and the international mobility of skilled workers are two important factors likely to affect the level of human resources available for innovation in Canada. These topics were the subjects of two earlier roundtables in this series. Another roundtable discussed a research

program on employer-sponsored training, which may become increasingly important as a source of skills as the proportion of recent school-leavers in the workforce decreases.[1]

1. Conceptual Framework for Indicators of Human Resources for Innovation

1.0. Conceptual Framework for Indicators—Introduction

A high level of innovation is one of the key features of a 21st century economy. *Achieving Excellence* identifies, among the elements of the national innovation system, "three key factors that profoundly influence innovation outcomes: knowledge performance, skills and the innovation environment". This section is concerned with developing indicators (benchmarks) of whether Canada will have a sufficient supply of skilled workers to support high levels of innovation. This is what *Achieving Excellence* describes as the "skills challenge".

Two questions arise from the foregoing: What qualifications typify the "skilled workers" needed to support high levels of innovation? What is a "sufficient supply" of skilled workers? The answers given to these questions are likely to depend on the model of the innovation process used. There is now an abundant economic and business literature on innovation and its determinants. It will not be the goal of this paper to review this literature in detail. The paper seeks, instead, to draw out the implications of the innovation literature for the levels and types of human resources and human capital investments that are required to sustain an innovative economy and to support rapid growth in the level of innovation in the Canadian economy.

The ultimate goal is to develop a set of indicators for human resources that can serve to identify potential human resources "bottlenecks" to growth in innovative activity in Canada. To do so will require a clear understanding of how different types of labour contribute to innovation, of how markets for these types of labour will adjust to rapid increases in the level of innovative activity and of the obstacles to adjustment in these markets. This will also yield a better appreciation of how large the required changes in the human resources available for innovation will be and of the effort that will be required in the area of human resources in order to move towards a more innovative economy.

The paper does not claim to establish the human resources requirements for a more innovative economy. It aims instead at outlining a program of research that could contribute to this end. Some suggestions are made as to the indicators implied by various views of the innovation process. In section 1.4, various indicators are related to the models of innovation that are discussed below. These indicators are presented as a preliminary attempt to benchmark where Canada now stands in terms of the human resources required for an innovative economy.

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[1] The issues papers prepared for the three earlier roundtables can be downloaded through http://strategis.ic.gc.ca/epic/internet/ineas-aes.nsf/vwGeneratedInterE/h_ra01877e.html

1.1. Models of the Innovation Process and Implications for Human Resources

Throughout the research literature on innovation, a skilled labour force is recognized as a crucial element for an innovative economy. Frequently, the type of human resources required for innovation is left unspecified beyond statements as to skill level. For example, Utterback and Afuah (1998, p.195) give as an advantageous factor condition "Large pool of skilled labor" in discussing elements of a firm's local environment that confer an advantage before the emergence of a dominant design.

There are nonetheless some models of innovation and of economic growth with direct implications as to the type of human resources required for an innovative economy. We discuss three of these in this section. The first two (those of Aghion and Cohen, 2003 and of Romer, 1990) are drawn from the "endogenous growth" literature. As in most of this literature, the analysis in these models is carried out at a very high level of aggregation, and concerns the effects of resource allocation on innovation and on economic growth. Their models do not treat the types of issues addressed by models of national innovation systems, (for example, OECD, 1997) which concern the actual processes by which knowledge is transformed into market value. Nor do these models address the reasons for differences in results with similar inputs.[2]

In contrast, the third paper discussed (Vernon, 1966) provides a model of how innovative activity is carried out. In its emphasis on costs of information acquisition and on externalities arising from proximity, it is closer to recent work on "innovation clusters" than to the endogenous growth literature. Vernon's paper also has very different implications from Romer's as to the key types of workers needed for innovation.

These papers are not discussed in order to reach a conclusion as to the mix of skilled workers required by an innovative economy. The reason is, instead, to pose the research questions that need to be answered before any conclusions can be drawn on these points.

Aghion and Cohen—Innovation and Higher Education

In a recent monograph, Aghion and Cohen (2003, pp. 23-31) present a model of the growth process in which the role of schooling differs between countries that are far from the technological frontier established by the leading economies and those countries that are near or at the technological frontier. Countries far from the technological frontier obtain productivity growth by the adoption of existing technologies, which is facilitated by an educated workforce. Countries near the technological frontier must innovate to attain continued economic growth. This requires a shift towards a greater emphasis on

[2] Porter and Stern (2004), in developing an index of national innovative capacity, build on the Romer (1990) model by adding institutional factors drawn from the national innovation systems literature. They use full-time scientists and engineers as a proportion of employment in a nation as one of three "base variables" determining national innovative capacity; the other two are population and the "stock" of international patents generated by a country between 1981 and 1995. The scientists and engineers measure is the only human resources index they use.

post-secondary education, in particular, on the higher levels of post-secondary education. As a result, the supply of the human resources required for innovation increases, thereby lowering their price and increasing the incentive for firms to engage in innovation.

Aghion and Cohen present estimates for a sample of 21 countries (including Canada) in support of their model. Their interaction terms between proximity to the technological frontier (measured by productivity relative to the United States) and the level of higher education are strongly positive. The implication for human resources from Aghion and Cohen's work is that countries such as Canada which are close to the technological frontier must innovate to maintain productivity growth and that to innovate these countries need to emphasize advanced post-secondary education.[3] These findings are similar to those of a recent paper by Krueger and Kumar (2003) who claim that the European focus on specialized, vocational education was responsible for most of the European-U.S. growth gap during the information age.

The implications of Aghion and Cohen's model for benchmarking depend on a country's distance from the technological frontier. The appropriate benchmarks for countries that are far from the technological frontier are broad measures of human capital, since a high overall level of human capital facilitates technology absorption. Countries like Canada that are close to the technological frontier typically have already achieved a high overall level of human capital. The appropriate benchmarks of human resources inputs to innovation for these countries concern the distribution of post-secondary graduates by level, and, in particular, the percentage of persons with advanced degrees in the workforce.

Romer—Production of Knowledge and Innovation

Romer (1990) develops a model of an economy with three inputs: capital, labour and human capital. These can be combined according to a series of recipes to produce output. Not all recipes are known, but new recipes can be discovered through applying a part of the stock of human capital to research activities.[4] The stock of knowledge refers to the recipes discovered to date; its growth rate is assumed to be proportional to the stock of human capital used in the research sector.

The economy in Romer's model has three sectors: a research sector that produces designs for new producer durables, an intermediate goods sector that uses the designs from the research sector and foregone output to produce the producer durables and a final output sector that uses labour, human capital and the producer durables. The greater the fraction of the economy's human capital devoted to the research sector, the greater the growth rate in output. A permanent increase in the stock of human capital in the economy leads

[3] Aghion and Cohen include the division of the population with higher education between innovative and imitative activities in their formal model, but do not discuss how this division evolves as the productivity frontier is approached. They also do not specify the type of work they mean when referring to workers with a higher education engaged in innovative activities, but much of their discussion later in the paper is in terms of measures of research and development, such as patent measures and publications measures.

[4] It is a simplifying assumption of the model that only human capital is used in the production of knowledge.

to increased knowledge intensity (the stock of knowledge increases relative to the capital stock) and to an increase in the proportion of human capital devoted to knowledge production.

This brief discussion has neglected many features of Romer's model. Since models of innovation are in their essence models of how knowledge is created and used, a brief aside to discuss his treatment of knowledge seems worthwhile. There are three types of knowledge in Romer's model: knowledge embodied in human capital, knowledge as recipes used in producing producer durables and recipes as additions to the stock of knowledge. Human capital is rival (can only be used by one producer at one time) and excludable. Recipes in use are non-rival, but excludable (through patents, etc.). Recipes as additions to the stock of knowledge (and therefore as an input to the production of new knowledge) are non-rival and non-excludable. The knowledge-producing sector is viable because it receives rents from producers who use the recipes it produces.

Like any model in economics, Romer's model is not meant to be taken as an exact description of existing economies. To the extent that it describes the essential features of the innovation process, it has clear implications for human resources. Two key variables are identified: the overall level of human capital and the fraction of human capital devoted to the research sector. The implied approach to benchmarking is the approach that is already widely used of developing benchmarks of the educational level of a national workforce on the one hand, and of the size of the national economy's research workforce on the other hand. Romer's model has little to say on the details of appropriate benchmarks, for example, who are the relevant researchers, but it provides a theoretical framework for this approach to benchmarking.[5]

Romer's model is an example of what is often characterized as an "inputs" or "linear" model of the innovation process, in which research and development inputs lead to additions to the stock of knowledge which lead to new products and processes. Romer does not model how decisions are made as to directions for research, nor the path leading from new knowledge to the implementation of an innovation. Thus Romer's model, like Aghion and Cohen's, may describe necessary human resources conditions for increased innovative activity, but does not shed light on how these resources, once available, are best used to increase innovative activity.

Vernon—Entrepreneurs, Managers, Feedback and Innovation

The benchmarking of innovative capacity has increasingly moved from measurement of inputs, such as the levels of research and development personnel, towards the national innovation systems approach. (OECD, 1997) There are many variants on this approach, but all rely heavily on various feedback mechanisms between researchers and other economic agents. Vernon's model of the innovation stage in the evolution of a product provides considerable insight into the possible role of feedback mechanisms in

[5] As noted above in footnote 2, it is the theoretical framework for Porter and Stern's (2004) benchmarking exercise.

innovation, as well as having direct implications for the type of human resources required for innovation.

Vernon's (1966) model extends beyond the phase of innovation, to discuss the maturing and the standardized product. His discussion of the innovation phase, however, includes many of the arguments used later in the innovations literature as to why innovative activity should be concentrated in local clusters within advanced economies.

Like Romer, Vernon views the existing stock of scientific knowledge as non-rival and non-excludable. Vernon gives a central role to entrepreneurs, who must bridge the gap between scientific discoveries and marketable products or processes. He directly ties his model to the costs of searching for information, in this case, information as to opportunities to introduce new products. These costs rise with distance, so that "producers in any market are more likely to be aware of the possibility of introducing new products in that market than producers located elsewhere would be". This argument has strong analogies with those used to explain why information externalities within geographically concentrated locations lead to the development of innovation clusters.

Vernon argues that since (at the time he was writing) consumer incomes were much higher in the United States than elsewhere and the United States had higher unit labour costs than elsewhere, entrepreneurs in the United States were more likely to be aware of opportunities to introduce new products that appeal to high-income consumers or to introduce new machinery or processes that are labour-saving. In this connection, Vernon notes (foreshadowing Porter's (1990) discussion of the initial development of clusters) that "Germany's outstanding successes in the development of plastics may have been due, for instance, to a traditional concern with her lack of a raw materials base, and a recognition that a market might exist in Germany for synthetic substitutes".

Vernon then develops a model of why, not only recognition of opportunities, but also initial production, occurs in proximity to the market for a new product or process. He cites three factors, first, a need for flexibility in changing inputs before the product is standardized, second, the high degree of product differentiation with associated rents in the early stages of development of a new product or process, and, third, that "the need for swift and effective communication on the part of the producer with customers, suppliers and even competitors is especially high at this stage", due to uncertainty as to the dimensions of the market, competitors' efforts and the specifications of the products most likely to be successful. (Once again, there are strong analogies with more recent literature on innovations systems and on innovation clusters). Vernon concludes that "all of these factors tend to argue for a location in which communication between the market and the executives directly concerned with the new product is swift and easy, and in which a wide variety of potential types of input that might be needed by the production unit are easily come by".

Finally, Vernon argues that with increasing standardization of a successful product, the lowest production costs become the overriding consideration, so that production shifts to the lowest cost location. This is easily translated into the language of more recent

discussions of the innovation process—as the required knowledge shifts from tacit knowledge to codified knowledge, production becomes more readily transferable to the lowest-cost location.

The essential insight of Vernon's model as to the location of production underlies much of the recent literature on innovation, in particular on innovative clusters. This is that in the innovation phase, information externalities and the availability of a wide variety of needed resources determine the location of innovative activities.

Vernon's model, however, draws out the human resources implications of this insight more clearly than much of the recent literature on innovation. His discussion of informational feedbacks from customers, suppliers and competitors implies that the role of the individuals involved in this feedback process, and those who furnish the services needed in an innovation cluster, are as crucial to the innovation process as the researchers who make the original scientific discoveries, which Vernon takes as given. In Vernon's model, entrepreneurs, those who provide services to entrepreneurs and entrepreneurs' information sources take a central role.

One set of communications channels that is neglected in Vernon's model are those between researchers and entrepreneurs. Because Vernon is principally concerned with the local concentration of the development of new products and processes from existing scientific discoveries, he takes the stock of discoveries as a given, known to potential entrepreneurs at every location. More recent work on innovation clusters emphasizes the importance of ease of interchange with leading-edge research as well as ease of interchange with potential markets for innovations. (Audretsch and Feldman, 2003, review "Knowledge Spillovers and the Geography of Innovation").

In Vernon's model, entrepreneurs, managers and feedbacks from the market play a crucial role in the innovation process. His model thus points to the human resources involved in these processes as crucial to innovation. As in the case of Romer's model, the exact set of persons involved is not specified. But if one thinks that Vernon's model (or other similar models) captures a crucial element of the innovation process, then one should seek to develop benchmarks for human resources for innovation that go beyond producers of new knowledge to include the human resources required to move from this knowledge to a viable innovation. In this respect, it seems worth noting that the OECD is currently developing benchmarks for enhancing knowledge-based management and organisation as part of a project to develop policy benchmarks for enhancing human capital and realising its potential.

Research Issues: Aghion and Cohen's work implies that there is an appropriate mix of types of education which depends on how close a country is to the technological frontier and the resulting level of innovative activity that is required for productivity growth. What is the appropriate distribution of levels of education for Canada and how close is Canada to that distribution? In particular, is Canada currently over-emphasizing tertiary education in community colleges relative to university education, in particular, to graduate programs?

Romer's work views the knowledge-producing sector of research and development as central to the innovation process. What human resources are required by the research needed for innovation? How can we measure progress towards meeting these human resources needs?

Vernon emphasizes the role of entrepreneurs and managers in moving from knowledge to innovation. Aghion and Cohen, 2003, cite Scherer and Huh (1992) as finding that firms' research and development expenditures increase with the level of technical education of their managers. This can be viewed as related to the idea of absorptive capacity—the "ability of economic agents to recognize, assimilate and apply new scientific knowledge". (Audretsch and Feldman, 2003, p. 19).

Are the human resources required to move from scientific knowledge to a marketable innovation as crucial to the innovation process as those involved in creating the scientific knowledge? More crucial? Complementary to research and development resources? Substitutes for research and development? What kinds of skills are needed by the entrepreneurs and managers who are responsible for useful innovations resulting from knowledge? Skills acquired through general education? Through managerial education? Through a combination of managerial and scientific education? What are appropriate ways to measure the adequacy of entrepreneurial and managerial skills for innovation?

What are the contributions of various types of labour to the level of innovation in firms and in the economy? How does this vary by sector? What is the degree of substitutability of various types of labour in the production of innovations? What are the implications for establishing benchmarks of the human resources needed for innovation?

1.2. Innovation in the Services Sector and Human Resources Implications

Both of the models discussed above are models of product or process innovation. As such they are most applicable to the goods-producing sector of the economy, although these models may apply reasonably well to some sub-sectors of services. Several observers have remarked that computer programs have many analogies with manufactured products. Vernon's model would imply that the "offshoring" of programming activities means that for certain types of computer programs, product features have become sufficiently standardized that production cost considerations prevail over product development considerations.

Other types of services, such as consulting services, are likely to produce a different product for each sale, rather than a standardized product. Although the Oslo Manual (OECD, 1996), which is used as a guideline to innovation surveys, has been revised in an attempt to better capture innovation in service industries, there seems to be a widespread view that there are continuing difficulties in this area.

Gallouj and Gallouj, (2000, p. 21) begins: "The economics of services is seeking a theory of innovation appropriate to its specific features. The bulk of the literature on 'innovation

in services' utilizes 'technologistic' and 'industrialistic' concepts and has in practice examined *technological innovations applied to services*". [italics in original] In the same volume Marklund (2000, p.94) notes that the conceptual framework for identifying and measuring innovation activities "has been focused on resources spent on R&D. However, R&D is only part of the innovation process and it is likely that the R&D concept, as it has been used in the regular R&D surveys, is much less adapted to service industries than manufacturing industries". He gives three main reasons: 1. these surveys emphasize technology and physical products, while service innovations seldom concern technology alone and are difficult to interpret in product terms; 2. service industries organize innovative activities in different ways than manufacturing firms; and 3. there are difficulties in separating products from processes in service production.

The services sector accounts for most of GDP and of employment in the advanced economies. There are, moreover, reasons for Canada to be particularly interested in innovation in the services sector. Canada has a relatively high proportion of its research and development expenditures in the services sector. (OECD, cited in Conseil de la science et de la technologie, 2003). A recent paper by Rao, Sharpe and Tang (2003) shows that while productivity is higher in both services and manufacturing in the U.S. than in Canada, productivity growth in services has been faster in Canada than in the U.S. (but slower in Canada in manufacturing). The authors cite faster growth in human capital levels in the services sector in Canada than in the U.S. as one of the sources of Canada's faster productivity growth in services.

Innovation surveys often do not include services, or are limited to a certain number of service sectors viewed as most likely to be innovative. For example, Statistics Canada's 2003 Survey of Innovation covered a selected group of knowledge-intensive service industries. It is not clear, however, that there has not been considerable innovative activity in more traditional service sectors, for example, the innovations made by Wal-Mart in the retail trade sector.

There is a certain amount of published literature on innovation in the services sector and how it differs from innovation in the goods-producing sector, but little information was found in the course of preparing this paper on the human resources implications of these differences. Marklund (2000) notes that most of the increase in employment of highly educated scientists and engineers in Sweden between 1987 and 1993 was in technology-related, knowledge-intensive business services, but that these firms engage in very little research and development activity as measured by R&D surveys. Firm-level data for Sweden show that "a large part of the highly educated scientists and engineers in Swedish industry are employed in firms that do not perform R&D in the regular sense". (p.102) His data show that this is true of a variety of services, including computer consultancy, but not for R&D services nor for manufacturing.

A recent publication of the Conseil de la science et de la technologie du Québec (2003) on innovation in the services compares Quebec and Ontario on the basis of a number of measures of scientific and technical personnel. The section in which this comparison is made begins by stating that innovation in the service sector is highly dependent on human

resources, then notes that the research-and-development-based measure of scientific and technical employees that is used does not take into account the innovative activities of other persons working in the service sector. In the event, by far the largest increase in employment in any of the groups examined was for computer programmers and analysts, whose employment in service industries increased by over 200% between 1990 and 2000 in both Québec and Ontario.

Finally, Hamdani (2003) provides evidence on the relation between the composition of skills within firms in a service industry and the level of innovative activity within the firm. He finds that in the Canadian engineering services industry, firms with a higher ratio of engineers to technologists were more likely to innovate. Firms with low engineer: technologist ratio that nonetheless innovated were likely to have done so by outsourcing or through alliances with other firms.[6]

Research Issues:

What are the human resources implications of the process of innovation in various services sectors? What are the differences between service sectors and with the goods-producing sector? What are useful benchmarks for judging the adequacy of the human resources in service sectors to support a high level of innovation?

1.3. Adequacy of Supply (Skill Shortages)

There is a large number of papers on various subjects concerning skill shortages. The title of a recent paper by Butz et al (2003) asks the questions "Is There a Shortage of Scientists and Engineers? How Would We Know?" Butz et al begin by considering five criteria by which the production of any good or service might be called low:

1. If production is lower than in the recent past.
2. If competitiors' share of total production is growing.
3. If production is lower than what the people producing would like.
4. If less is produced than the nation is deemed to need.
5. If production is not meeting market demand, as indicated by a rising price.

One might add a criterion 4a—if less will be produced than is likely to be required to meet some stated national goal. As an example of this approach, Laciak (2002) is a careful examination of the implications in terms of the production of scientists and engineers of meeting Canada's stated goal of becoming one of the leading nations in the percentage of GDP devoted to research and development.

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[6] Another finding cited in this paper has implications for the measurement of innovation in consulting services. It is that the principal methods of protecting intellectual property in this sector are being first to market and technological complexity. First to market was used by twice as many firms as used legal forms of protecting intellectual property. The implication is patents or other forms of protection of intellectual property rights to measure innovation may not be a good measure of innovative activity in service industries.

Butz et al. point out that only their fifth definition involves a self-correction mechanism—increased supply in response to a rising price. Romer, 2002, however, describes institutional reasons that this mechanism may not function to assure supply adjustments for scientists and engineers. With respect to the fifth definition of shortage, the authors note that earnings of scientists and engineers are lower than those of persons holding professional degrees, that unemployment rates for scientists and engineers in some fields rose in the 1990's in the U.S. while overall unemployment rates fell, and that time to degree is highly variable and has increased on average for scientists and engineers, but is much less variable and has not increased for professional degree holders. They conclude that the attractiveness of degrees in science and engineering has decreased, relative to various professional fields.

Their analysis is an excellent example of the use of various benchmarks to judge whether there is a shortage of a given type of labour. Canadian data from the Census and the National Graduates Surveys (NGS) and Follow-Ups would support a more complete analysis than that carried out by Butz et al. Finnie and Lavoie (1997) have used the NGS to examine the job market for graduates in science and technology and have found evidence of persistent weak labour market conditions. The Expert Panel on Skills (2000) states that "[o]f far greater concern than a lack of skills is a *shortage of opportunities* in Canada" (p. 31).

An analysis of this type can identify the reasons that production of some type of labour has failed to meet some deemed national need (criterion 4 or 4a). It may also permit identification of prolonged situations of disequilibria, after which one could examine the reasons for a failure of supply to adjust. This does not necessarily imply however that benchmarks of this type can be used to project future failures to meet a goal or future disequilibria.

It is also the case that this analysis is carried out at a high level of aggregation. Skill shortages as perceived by firms, industries and government are often much narrower in scope. It might be illusory, given lags in data availability and lags in the production of skilled labour, to think that shortages in the production of skilled labour can be identified rapidly enough for policy to act to eliminate these shortages before market adjustments have done so. The boom-bust cycles in computer science graduations are a cautionary tale in this respect.

Research Issues:

Can benchmark data be used to anticipate skills shortages for skilled labour at a very aggregate level (for example, scientists and engineers)?

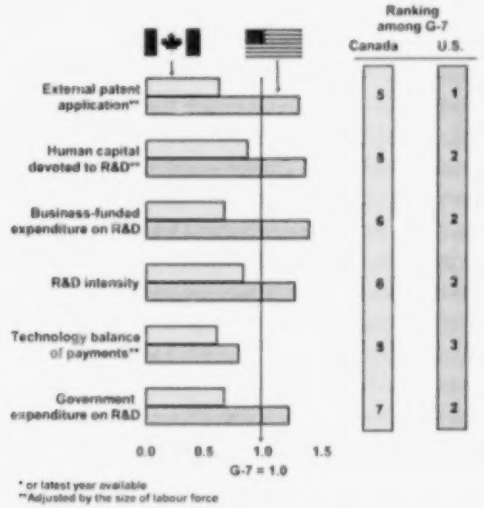
What do case studies show as to the time required to identify skill shortages for specific types of skilled labour, relative to the time required for market corrections to occur (increased supply, slowing of demand)?

1.4. Human Resources Needed for Innovation—Preliminary Indicators of Canada's Position

Canada's Innovation Performance

Canada's position with respect to the human resources needed for innovation is a key part of Canada's overall innovation performance. *Achieving Excellence* states (p.16) that "Canada's overall level of innovation capacity is near the bottom in the G-7". Figure 1 below is an updated version of the chart provided as evidence for this statement. Canada is no better than fifth in the G-7 on each of the indicators used in this chart and is behind the U.S. with respect to all of these indicators. Of particular interest for this paper, Canada is fifth in the G-7 for the indicator "human capital devoted to R&D", while the U.S. is second.

Figure 1: Canada's Innovation Performance (Standing Relative to G-7, 2002)

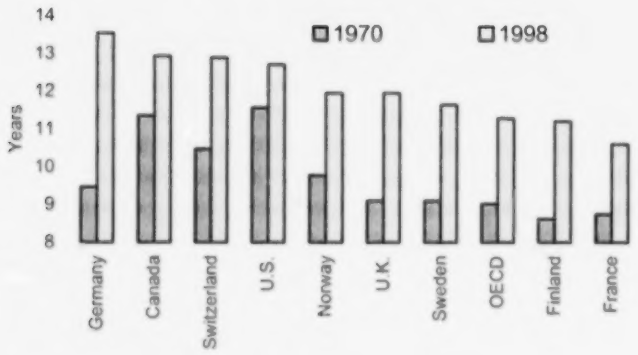


Source: OECD, Main Science and Technology Indicators, 2003-1

Level of human capital

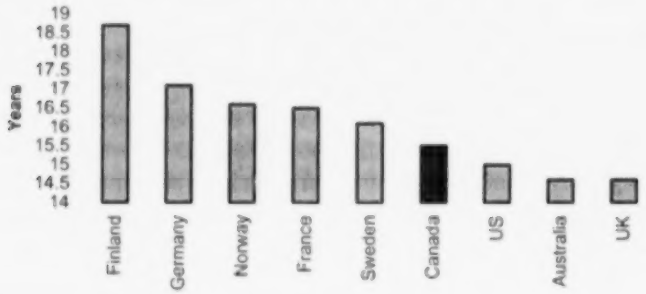
Most models of innovation examined identify a country's level of human capital as one of the key determinants of its innovative capacity. Canada's standing in this respect has been well documented. Consequently, this section will be short and will concentrate on pointing out areas of potential weakness, as shown by international comparisons.

Figure 2: Average Years of Education of 15-64 Year Olds Across Selected OECD Countries



Source: OECD, Bassanini, Scarpetta and Hemmings, 2001.

Figure 3: Expected Years of Full-time Schooling, Excluding Education for Children Under Five Years of Age, 2000

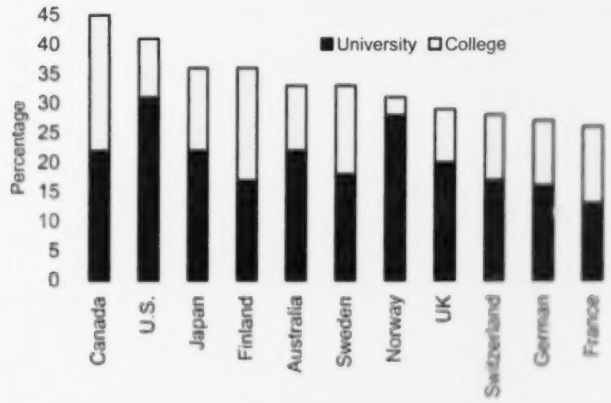


Source: OECD, Education at a Glance, 2002.

Canada compares well to other OECD countries in terms of the educational attainment of its working age population (Figure 2). Moreover, Canada has made important gains in this respect over the last thirty years. The gains have been even larger in other countries, however. Based on current age-specific schooling data, Canadian children will ultimately complete fewer years of schooling, on average, than those of many other OECD countries (Figure 3).

Thus without changes, Canada's future labour force entrants will be less skilled than those of many other OECD countries. The principal sources of weakness are high school non-completion rates (which remain high, despite recent gains), lower post-secondary enrolment rates among high school completers, a greater propensity to complete shorter college programs, rather than longer university programs, and a lower propensity to complete graduate degrees. All of these statements apply more to Canadian men than to Canadian women (except at the doctoral level).

Figure 4: Distribution of Labour Force by Tertiary Level Education, 2001.

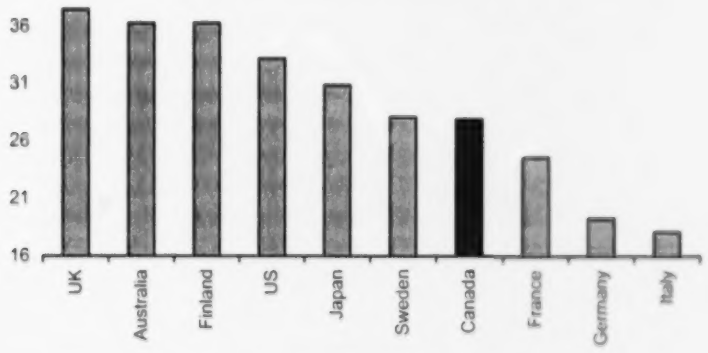


Source: OECD, Education at a Glance, 2002.

It is often stated that Canada has the highest percentage of persons in the labour force with a tertiary-level educational qualification (Figure 4). This is true, but only because of the very high percentage of the labour force with college and trades qualifications in Canada. Canada has a percentage of the labour force with university degrees (22%) which is identical to Japan and Australia, slightly ahead of the United Kingdom (20%) and far behind the U.S. (31%).

As discussed above, in particular, in the context of Aghion and Cohen's (2003) model, the appropriate relative proportions of university and college degree holders will be an important issue to address in research on human resources for innovation. It is clear that Canada has invested more heavily in college-level education than other advanced economies, in particular, the U.S.

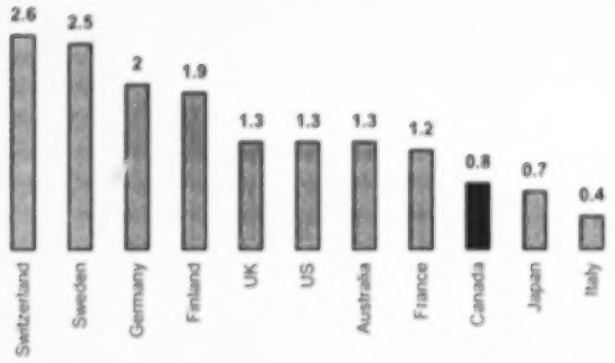
Figure 5: Graduation Rates from University, 2000



Source: OECD, Education at a Glance, 2002.

Also, Canada is not catching up in university graduations at present. Graduation rates from university-level education are higher in many other OECD countries (Figure 5), including the U.K., Australia, the U.S. and Japan.

Figure 6: Graduation Rates from PhD Programs, All Fields, 2000



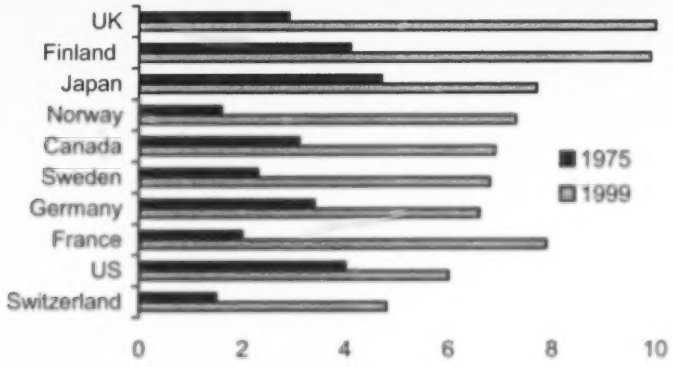
Source: OECD, Education at a Glance, 2002.

Finally, Canada is also behind in graduation rates from advanced research programs (Figure 6). The Aghion-Cohen model suggests that a shift towards higher levels of qualifications, such as advanced research degrees, is required in order to move towards a more innovative economy.

Human Resources in Science and Engineering

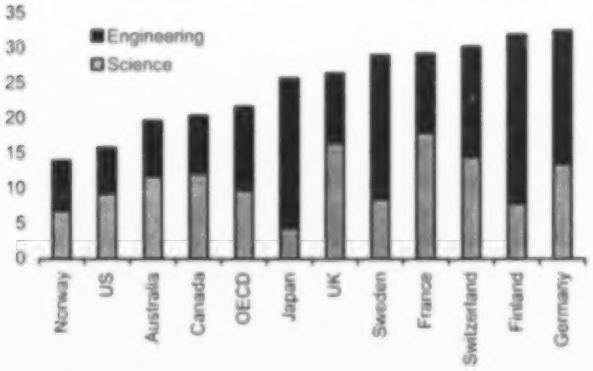
As noted above, different models of the innovation process lead to differing views of the relative importance of scientists and engineers and of other types of workers (for example, managers) to innovation performance. Few would deny, however, that scientists and engineers play an important role in innovation, in particular, those scientists and engineers engaged in research and development. This section presents some summary indicators of how Canada stands with respect to the science and engineering workforce. The flow of entrants in science and engineering is examined first.

Figure 7: Graduation Rate of S&E Undergraduate Degrees



Source: Benchmarking Education and Training for Economic Development in Ireland, 2003.

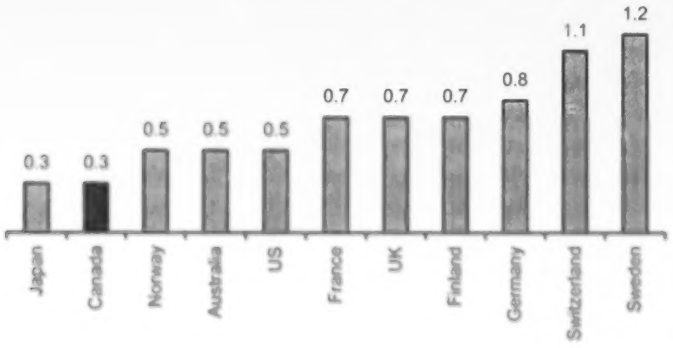
Figure 8: Degrees in S&E as a Percentage of New Degrees, 2000



Source: OECD, STI Scoreboard, 2003.

As part of the rapid increase in university-level education, the output of science and engineering undergraduate degrees doubled from 1975 to 1999 (Figure 7). Over this period, Canada made rapid gains in the percentage of youth with science and engineering undergraduate degrees. Gains in other countries were even larger, however, so that the gap between Canada and several other OECD countries (but not the U.S.) widened. Science and engineering degrees—and in particular engineering degrees—are a much higher proportion of undergraduate degrees in several countries than they are in Canada (Figure 8).

Figure 9: PhD Graduation Rates in Science and Engineering, 2000

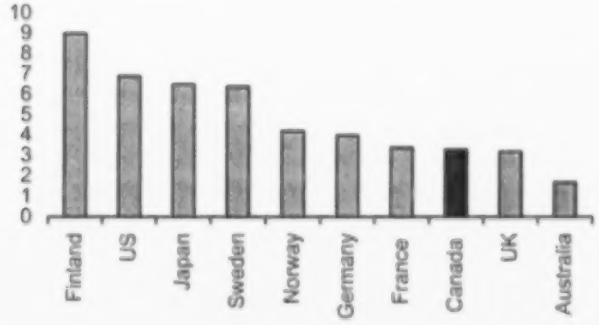


Source: OECD, Education at a Glance, 2002.

The percentage of graduates with doctorates in science and engineering is much lower in Canada than in many other OECD countries, including the U.S. (Figure 9). The principal source of this gap is low levels of overall doctoral output in Canada, since a high percentage (around 40%) of Canadian doctoral output is in science and engineering fields.

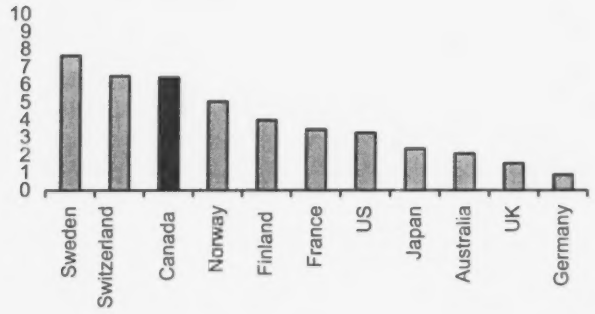
Researchers in the business sector

Figure 10: Business Sector Researchers Per Thousand Total Employment, 2001 (or most recent)



Source: OECD, STI Scoreboard, 2003.

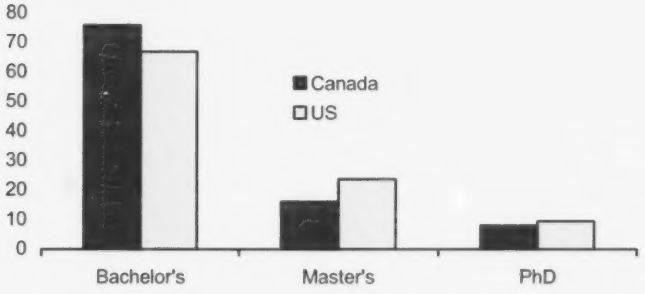
Figure 11: Growth of Business Researchers, Average Annual Growth Rate 1991-2001 (or most recent)



Source: OECD, STI Scoreboard, 2003.

Greatly increased levels of innovation in Canada are likely to require increased research and development activity in the business sector. Canada ranks behind several OECD countries, including the U.S. and Japan, in researchers as a percentage of employees in the business sector (Figure 10). On a more promising note, Canada had one of the highest growth rates in the number of researchers in the business sector between 1991 and 2001 (Figure 11).

Figure 12: Distribution of Research Scientists and Engineers in Business Sector by Degree Level, 1999



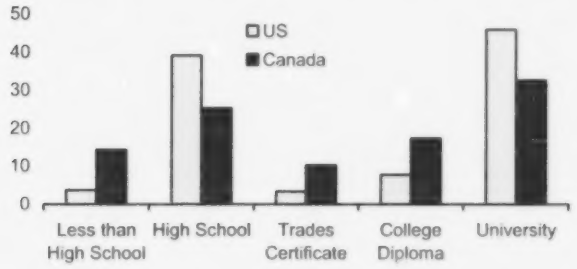
Source: "An analysis of the Supply/Demand Conditions to 2010 for R&D Personnel in the Sciences and Engineering", 2002.

Canada lags the U.S. not only in the percentage of researchers among business sector employees, but also in the educational level of researchers (Figure 12). Canadian business-sector researchers are much more likely to have a bachelor's degree than their American counterparts, and are correspondingly less likely to hold an advanced degree.

Managers and entrepreneurs

In a number of models of innovation, including Vernon's product cycle model discussed above, managers and entrepreneurs play a key role in innovation. It is more difficult to find indicators for the capacity of managers and entrepreneurs to contribute to innovation in Canada than to find such indicators for scientists and engineers. It would seem likely, however, that a better-educated managerial workforce is better able to contribute to innovative activity.

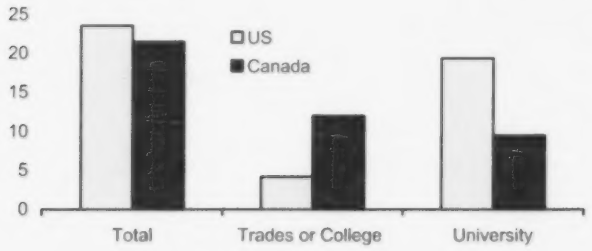
Figure 13: Managers by Educational Attainment, Canada, U.S. 1996



Source: Statistics Canada, 2001 Census, and "What's It Worth? Field of Training and Economic Status, 1996", US Census Bureau.

Canada clearly lags behind the U.S. in this respect (Figure 13). A much higher proportion of Canadian than American managers have not graduated from high school. A much higher percentage of American than of Canadian managers are university graduates.

Figure 14: Distribution of Managers by Business Education, Canada (2001), U.S. (1996)



Source: Statistics Canada, 2001 Census, and "What's It Worth? Field of Training and Economic Status, 1996", US Census Bureau.

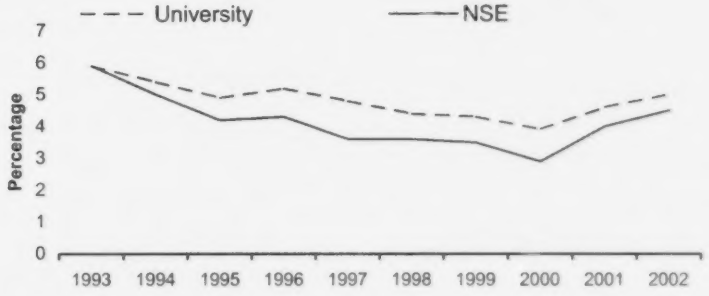
The gap between Canada and the U.S. is small in the percentage of managers with formal tertiary-level business education, but the greater prevalence of collegial education in Canada than in the U.S. can be seen once again (Figure 14). Canadian managers are much

more likely to have had business training at the collegial level and much less likely to have had business training at the university level than their American counterparts.[7]

Adequacy of Supply—Scientists and Engineers

Examination of a variety of indicators, as in Butz et al, is likely to be the best approach to determining whether there are persistent shortages of labour supply in an occupation. Since the goal of this paper is not to determine whether there is a persistent skill shortage in some sector or occupation, only a single indicator is examined here as an example of a possible indicator. The unemployment rate of scientists and engineers is compared to the unemployment rate of all university graduates.

Figure 15: Unemployment Rates by Level of Education and Field of Study, 1993-2002



Source: NSERC, Departmental Performance Report, 2003, Figure 32, and Statistics Canada, Labour Force Survey.

If there were a growing shortage of scientists and engineers in Canada, one would expect very low unemployment rates for this group, and an increasing divergence between the unemployment rates of the two groups. In fact, over most of the period considered, scientists and engineers have a lower unemployment rate than all university graduates (Figure 15). The gap was around one percentage point from the mid-1990's to 2000. From 2000 to 2002, the gap narrowed from one percentage point to half a percentage point.

Thus on the basis of this indicator one would conclude that the labour market position of scientists and engineers is somewhat better than that of university graduates as a whole, but that this advantage has eroded recently. This would not seem to indicate a persistent and growing shortage of scientists and engineers.

[7] Definitions of managers differ between countries (and between surveys in the same country), so that some managers in Canada in these comparisons might not be classified as managers in the U.S. and vice versa. Since managers are a larger proportion of the total workforce in the U.S. than in Canada in the data used here, it is unlikely that the differences in managerial educational attainment are due to differences in how managers are classified.

Conclusion—Indicators

This section presented a variety of possible indicators of the availability of the human resources needed for innovation. More indicators were presented for overall levels of human capital and for scientists and engineers and for workers in research and development than for other groups that may play a key role in innovation. This divergence reflects the availability of indicators, not the relative importance attached to the various types of human resources. Better indicators for managers and entrepreneurs involved in innovative activities need to be developed. Better indicators for workers involved in innovative activities in services are also needed.

2. Institutional Factors and Labour Market Adjustments

Section 1 of this paper considers issues of the adequacy of the supply of skills and of labour market adjustment at a high level of aggregation. Similarly, the paper by Claude Montmarquette and David Boisclair (2004) examines the role of the post-secondary educational system in adjustments in the overall market for skilled labour.
It is likely to be equally important to examine labour markets at a much finer level of detail in seeking to identify how institutional factors can influence the availability of human resources for innovation. Harberger (1998) argues for the importance of industry- and firm-level detail in understanding growth in total factor productivity (TFP) and, in particular, in understanding the role of externalities related to human capital in TFP growth.

Much of the discussion to date of issues of the availability of human resources at a detailed level has been in terms of "skill shortages" and "skill surpluses". To arrive at a clear definition of "skill shortages", the Expert Panel on Skills (2000, p.15) distinguishes between "imbalances" and "skill shortages". The panel's report reserves the term "skill shortage" for "a *persistent* shortfall in the supply of qualified personnel at the prevailing wage or salary levels". The report states that "employers may express concerns about skill shortages when they offer the wages they are accustomed to paying for a given set of skills, and suitable candidates do not apply for the job", but this does not necessarily mean there is a skill shortage, rather than an imbalance. The report goes on to define adjustment mechanisms that tend to correct imbalances: increased supply from entrants: training in the required skills and workers with closely related skills in response to opportunities, changes in hiring requirements, substitution or reduced production plans for firms.

This section of the paper thus raises for discussion various institutional features that might create a "*persistent* shortfall of qualified personnel" and institutional arrangements that might facilitate labour market adjustments. These will be taken up under the following headings: institutional factors that may prevent entry, mobility or substitution, institutional arrangements that could facilitate adjustments through re-skilling, provision of information, and possible market imperfections. The emphasis will be on the types of skills required for innovation.

2.1. Institutional Factors that Might Impede Entry, Mobility or Substitution

Many groups of skilled workers face accreditation requirements in various jurisdictions. In the context of the Labour Mobility Chapter of the Agreement on Internal Trade, 51 occupations were identified as regulated in at least one Canadian jurisdiction. These barriers are estimated to limit mobility for 15-20% of the labour force. (HRDC, 2001) Regulation and accreditation may impede labour market adjustment in two ways. First, they may impede geographic mobility of skilled labour, either by blocking entry to an occupation in a jurisdiction or by increasing the costs of mobility (for example, by imposing fees for examinations or by requiring time-consuming and costly courses).

Second, regulation and accreditation may slow adjustment by limiting the possibilities for substitution. For example, certain engineering activities are limited to professional engineers. This limits the degree to which workers other than professional engineers can be substituted for professional engineers when demand for professional engineers increases. While regulations of this type may have an important role in ensuring public safety, this role needs to be validated and balanced against the limitations to labour substitution that result. Barriers of this type have been widely discussed in connection with immigration, but also apply to internal migrants. [8]

Lack of portability of various employment-related benefits may also be an impediment to worker mobility between regions, sectors or firms. This could be particularly applicable to very high-skilled personnel if a large part of their compensation is in entitlements that effectively require these workers to remain with their employer in order to realize them (for example, stock options).

Much of the recent research literature on innovation concerns a geographic entity, innovation clusters. (See Audretsch and Feldman, 2003 for a review). Presumably the development of a cluster involves the internal or international migration of skilled workers towards a specific geographic location. Impediments to migration towards innovation clusters could have a particularly unfavourable impact on the innovation capacity of an economy. Issues concerning clusters might include whether competing attempts to build clusters in the same fields may impede mobility towards the location with the best chances of success.

The Audretsch-Feldman review takes up (pp. 21-28) issues of entrepreneurship as a spillover mechanism. The essential idea is that a start-up may be the best way for an innovator to capture the return to innovation. Since innovators launching start-ups will consider various locational advantages, institutional impediments to business entry might be a significant barrier to mobility of this type.

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[8] Issues of international mobility of skilled workers are discussed in the issues papers for the roundtable on the "International Mobility of Skilled Workers". Both of these papers are available at http://strategis.ic.gc.ca/epic/internet/ineas-aes.nsf/vwGeneratedInterE/h_ra01877e.html.

An obvious possible source of an increased supply of science and technology skills would be an increase in the number of women entering these fields. The continuing increase in the percentage of women among post-secondary graduates means that it will be very difficult to increase the share of science and technology graduates, without large gains in the percentage of women in these fields of study. Identifying and removing any institutional barriers to women's entry in these fields could make a significant contribution to the supply of human resources for innovation.

Issues for discussion: Do we have sufficient information on the geographic mobility of skilled workers? Do we have sufficient information on the role of labour mobility in building innovative clusters? Do accreditation requirements and other regulations pose significant impediments to adjustments through substitution in markets for skilled labour? to adjustments through internal migration? Are there institutional obstacles to women entering fields in science and technology, and if so, what are these obstacles?

2.2. Institutional Arrangements that Could Facilitate Adjustments through Re-Skilling

It seems likely that rising levels of skill have been associated with increasing specialization of technical skills. On the other hand, the Expert Panel on Skills (2000, p. 2) found "no current evidence of a generalized and persistent shortage of *technical skills*" but "a persistent shortage of people who combine strong technical abilities with *essential skills* (e.g., communications and teamwork) and *management skills* (e.g., cost control and budgeting)".

This points to a possible need for better institutional arrangements to facilitate adjustments in two areas. The first area is the provision of re-skilling mechanisms for persons whose highly specialized technical skills become obsolete in whole or in part. This could facilitate adjustment by making it easier for skilled workers to move from one type of specialization to another, thus reducing the risk workers incur by investing in very highly specialized human capital.[9] The second area where better institutional arrangements may be needed is in training or education in various business and essential skills.

The present knowledge base on re-skilling for skilled workers is limited. It is not obvious that the present approaches to training and education are necessarily the best. For example, Butz et al (2003, p.5) note that time to complete a doctorate in natural sciences is highly variable and has been increasing over time, while time to various professional degrees has remained constant. They cite this as a reason that professional degrees may be increasingly attractive, relative to careers in research and development in the natural sciences. (A shorter time to degree increases the return to education by shortening the period of foregone earnings). The major increases in research and development are expected to be in the private sector, yet as Romer (2001) notes "the existing system of

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[9] International labour mobility may be another mechanism that reduces this risk., as discussed in the issues papers for the roundtable on "International Mobility of Skilled Workers". See http://strategis.ic.gc.ca/epic/internet/ineas-aes.nsf/vwGeneratedInterE/h_ra01877e.html.

graduate education seems [so] poorly suited to training people for careers outside of academic science".

Butz et al envisage the possibility of professional-style doctoral degrees in natural sciences for persons interested in private sector research careers. This might provide the basis for better institutional arrangements for providing highly skilled, highly specialized human resources with the essential and management skills businesses need. Essential and management skills might be acquired through training and schooling cycles after the doctorate, combined with periods of work in the specialty area. The British "Skills for Business" program cited by the Expert Panel on Skills (2000, p.75) is a possible model.

Issues for discussion: Do we have an adequate understanding of how retraining needs differ by skill level and what the needs are at high skill levels? Are there institutional changes which would facilitate re-skilling in specialized technical skills for skilled workers? Are there institutional changes which would improve the acquisition of essential and managerial skills by persons with high levels of technical skills?

2.3. Provision of Information

Provision of labour market information is widely seen as way of improving labour market adjustment. Montmarquette and Boisclair (2004) discuss the role that better information could have in improving potential students' decisions as to whether to pursue post-secondary education and in what field of study. Romer (2001) claims that the lack of availability on returns to careers in natural sciences and engineering is a factor in the low supply of new researchers in these fields in the U.S.

The questions in this area would seem to be what sort of information is credible and who should provide it. According to the Expert Panel on Skills (2000, p.15) "Predicting exactly how many workers with specific sets of skills will be required in a given industry in five to 10 years' time is as difficult as predicting the amount of rain that will fall on a certain date two months away". The conclusion would seem to be that it is not worth attempting to provide information at this level of precision.

Economists tend to view markets as devices for providing information. (For example, see the discussion in Roy et al, 1996). If one accepts this view, the best channel for providing information would be market channels. For example, firms would seem likely to have the best information as to their present and probable future needs for various types of technical skills. A firm that provided a training grant in a specialized area to doctoral students would be furnishing highly credible information on labour market needs. Firms may fail to do so because the skills thus acquired could be used by competitors as well as themselves (although as Montmarquette and Boisclair point out, there are possible contractual arrangements by which firms could protect themselves against this risk). For highly specialized skills, however, this objection would not seem to apply at the sectoral level. Perhaps arrangements of this sort at a sectoral level are the best way to provide information on future needs for highly specialized skills.

The "Report of the Expert Seminar on Labour Market Monitoring and Information" (Sangster, 1999, pp. 6-7) notes the need to develop objective measures of skills and to gather data on these skills in order to provide the information required for skills-based monitoring. Both of these types of information could facilitate labour market adjustment. If there were suitable objective measures of skills, many workers might seek to take these tests, both to identify areas of weakness where they might seek training and to provide certification for their skills. Better data on skills would aid employers and sectors in adjustment.

The question of who should provide these types of information remains. There is an existing industry for providing tests of various skills for employers and for employees, although one might certainly envisage a government role in certifying the objective nature of these tests. (Computer software companies, however, certify skills in the use of their software on a private basis). Data collection on the level and distribution of various skills in the workforce perhaps is best carried out by a government statistical agency.

Issues for discussion: What kinds of labour market information are likely to facilitate adjustments in markets for skilled labour? Are markets providing sufficient information for adjustments to proceed? What is an appropriate level of detail? How can credible information be provided in a timely fashion? Who should provide various types of information? How does the present system of labour market information do in meeting these standards?

2.4. Market Imperfections

As noted above, the increase in the level of technical skills that characterizes the knowledge-based economy is likely to be accompanied by increasing specificity of these skills. A general conclusion of recent literature on training is that asymmetries of information, for example, between a worker's present employer and other possible employers, may lead to under-investment in skills, which would impede adjustment. (Models of this type are reviewed in Lin and Tremblay, 2003). Another possible consequence is decreased mobility of workers, again leading to decreased labour market adjustment.

There are reasons to think that information asymmetries may increase with skill level. Recruitment costs are likely to be higher as skill levels rise. It is likely to be far more time-consuming and potentially expensive to determine the skill level of newly hired, specialized workers by monitoring their job performance than is the case for less-skilled, less-specialized workers.

Another form of market-related adjustment difficulties may arise because markets for highly specialized workers have few participants in a small economy like Canada's. For example, much of the research and development activity in Canada in certain specialized areas may be carried out by a small number of firms, or by one firm only. On the other

hand, if the international mobility of skilled labour is increasing, this may offset the effect of a small number of potential employers in the Canadian economy.[10]

Issues for discussion: As Canada moves towards a more innovative, knowledge-based economy, are market imperfections in markets for highly specialized labour likely to be an increasing impediment to adjustment?

2.5. Supply and Demand for Skilled Workers

Until now, this section has considered various obstacles that could impede adjustment in the supply of skilled labour. Indeed, the paper to this point has largely concerned issues of supply. The Expert Panel on Skills (2000, p.6), however, under the heading "Knowledge", states as "the challenge: skilled Canadians are facing a shortage of opportunities". Clearly, there is little point in undertaking measures to increase the supply of skilled workers, if the demand for their skills is insufficient to allow them to earn a market rate of return on their investment in skills. The Innovation Agenda is a policy initiative aimed at increasing innovative activities to a level that would greatly increase the demand for skilled workers. (Laciak, 2002, provides estimates of the implied increase in requirements for scientists and engineers in research and development). Research in the U.S. (for example, Butz et al, 2003) and in Canada (Finnie and Lavoie, 1997) does not suggest that the labour market for scientists and engineers has been characterized by persistent skills shortages in recent years.

A final issue for discussion is then, what is likely to be the relative importance of supply-side and demand-side impediments in ensuring that Canada has the skills required for an innovative, knowledge-based economy?

3. Conclusion

This paper discussed a broad range of knowledge gaps in our understanding of adjustments in markets for skilled workers in Canada. The companion issues paper by Montmarquette and Boisclair (2004) examines a key aspect of adjustment—the adjustment of the post-secondary educational system to changes in the labour market. Issues papers prepared for earlier roundtables in this series discussed related issues—the effects of population aging on the labour market and on skills, international mobility of skilled labour, and employer-sponsored training, which may become an increasingly important source of skills.[11]

The goal of the entire process is to support policy-making by adding to our knowledge of the skills and human resources needed for innovation. This paper examined two subjects

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[10] The question of whether international mobility of skilled workers is increasing is discussed in the issues papers for the roundtable on the "International Mobility of Skilled Workers". See http://strategis.ic.gc.ca/epic/internet/ineas-aes.nsf/vwGeneratedInterE/h_ra01877e.html

[11] All of the issues papers from the Skills Research Initiative Roundtables are available at http://strategis.ic.gc.ca/epic/internet/ineas-aes.nsf/vwGeneratedInterE/h_ra01877e.html.

within this area: first, what are appropriate indicators of how Canada is progressing towards guaranteeing an adequate supply of the skills needed for innovation, second, what aspects of sectoral and regional adjustment processes might involve frictions that would cause difficulties for guaranteeing an adequate supply of the skills needed for innovation.

Policy for innovation increasingly will require a better understanding of how different economic actors—skilled workers and entrepreneurs in particular—combine and interact to produce an innovative economy. Policy will require indicators for judging progress that are based on this understanding. Finally, identification of barriers to labour market adjustment will allow policy actions to address these barriers.

There are a large number of potential areas for research on these subjects. The first role of this workshop is to identify those areas in which progress in our understanding can be made within the time frame of this project. The workshop's next role is to establish priorities among feasible research areas as to which can make the most significant contributions to formulating policy. The final role of the workshop is to help reach a better formulation of the research issues.

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